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RUNOFF OF OILS FROM RURAL ROADS
TREATED TO SUPPRESS DUST

Frank J. Freestone

Edison Water Quality Research Laboratory

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TREATED TO SUPPRESS DUST

Frank J. Freestone
Edison Water Quality Research Laboratory
Edison, New Jersey 08817

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ABSTRACT

Two rural roads in Readington Township, Hunterdon County, New Jersey, which are treated with waste crankcase oils, were examined to determine whether or not the oil leaves the road. Analyses indicated that roughly one percent of the total oil estimated to have been applied remains in the top inch of road surface material, that oil penetration below the top inch of road was minimal, and that lead was concentrated (≈ 200 mg/kg) in the top inch of road material.

Laboratory weathering experiments indicate an estimated maximum weathering loss of oil from a road would be approximately 18%. Rain runoff studies on simulated rural road surfaces indicated two mechanisms by which oil is transported from the road: leaching of the oil by flotation, and flotation of oil-wet soil particles. The greatest oil transport is during the first few rains after oil application with continuous, low level leaching during each subsequent rain.

Analysis of soil samples taken from a field subjected to runoff from an oiled road showed significantly higher lead content than soil taken from a field 150 feet from the road.

Five photographs, clearly showing oil leaching from the test road surface and entering drainage ditches after a rain, are presented.

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SECTION I

CONCLUSIONS

1. Roughly 1% of the total oil conservatively estimated to have been applied to the test roads remains in the top inch of road surface. Penetration of oil below this top inch is minimal.
2. Oil leaves the road during wet weather by flotation from wet road surface material and by flotation of oil-wet road surface particles.
3. Lead, which is contained in the waste crankcase oil, also leaves the road surface with runoff.
4. The road surface contains a considerable amount (≈ 200 mg/kg average) of lead, which, if associated with dust particles on the road, could be carried by winds to contaminate fields and crops adjacent to the oiled road. This could be a problem where road side crops are for direct human consumption, such as lettuce, cabbage, etc., and/or where lead from the oiled road adds to the lead fallout on these crops from vehicular traffic.
5. Precise quantitation of oil movements was beyond the scope of this study; only estimates of major oil movements were made. The estimates apply most specifically to the roads tested, and will vary somewhat with other roads and oiling conditions. Therefore, extrapolation of these data to other roads must be made with care.

SECTION II

RECOMMENDATIONS

1. Further study to determine the quantity of waste oils that actually leave the roads should not be undertaken at this time. The fact that the oil leaves the road is clear; precise quantitation is not easily achieved.
2. Further study should be undertaken to determine the ecological consequences of runoff oil and its accompanying heavy metals, including lead.
3. If preliminary evidence from the study of (2) above indicates ecological harm, then studies should be undertaken to define economically attractive alternatives to the application of waste oils for dust control, and means for implementation of the alternatives.

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SECTION III

INTRODUCTION

An estimated 200 million gallons of waste crankcase oils and an unknown quantity of other waste oils, are applied yearly to rural roads in this country for the purpose of dust control.¹ The waste crankcase oil contains approximately 1% by weight of lead compounds which amounts to 14.0 million pounds of lead applied yearly to roads.

In Readington Township, Hunterdon County, New Jersey, dirt roads are oiled twice yearly, in June and August to suppress dust in front of houses along the roads. Two of the roads in Readington Township were examined to determine if the waste oils were leaving the road surfaces. The problem was approached by attempting a mass balance to determine the amount of oil applied to the road surface, the amount remaining in the road surface, and the amounts leaving the surface by various mechanisms. Additionally, analyses were made to determine if the lead component of the oil was also leaving the road.

The top inch of road surface material extending the width of the road between drainage ditches was considered the object of the mass balance. Oil could leave the road surface by several mechanisms: volatilization, runoff mechanisms, adhesion to vehicles passing (with possible redeposition at other areas), adhesion to dust particles with wind transport from the road surface, or penetration into the road material below the surface, possibly through capillary action. Additionally, the oil remaining in the road surface could be biodegraded.

Some of the variables affecting the above movements are oil application history, frequency, quantity per application; oil type, source, viscosity, density, volatility, presence of surface active agents; road conditions: crown, slope, compaction, density and porosity of soil, soil grain size distribution; traffic conditions on the road; weather conditions: time to the first rain after oil application, total yearly rainfall, temperature affecting volatility of oil, wind affecting dust transport; and factors affecting biodegradation: presence of oil-consuming microorganisms, road surface moisture content and presence of nitrogen and phosphorous nutrients.

With such a range of variables and oil movement mechanisms, precise quantitation of oil movement applicable to numerous roads is beyond the scope of this study. However, with information available, estimates may be made of some of the more significant movements of oil.

SECTION IV

EXPERIMENTAL

1. Oiling History

No records are available of the true oiling history of the test roads. The Readington Township Clerk indicates that the roads have been oiled twice yearly for at least 12 years. The waste oil collector who has done the oiling indicates the roads have been oiled by him for 16 years, since 1955, and by others before him for an unknown number of years. Road oiling to lay dust is usually done in other townships in response to complaints from persons living along the roads; thus during dry years the roads may be oiled twice, and in wet years once or not at all. A conservative estimate of the total number of oilings on the test roads is 24, considering 2 oilings per year for 12 years, with the understanding noted above.

2. Oil Type and Application Rate

The oil type and application rate is highly variable. Conversations with the waste oil collector who oils the Readington roads indicates that he uses a mixture of #4, #5, or #6 fuel oil sludge obtained from tank cleaning operations, and waste crankcase oils collected from service stations in the Trenton, New Jersey area. The ratio of the mixture depends upon the availability of the fuel oil sludge, and ranges from 15 to 30% sludge, the balance being waste crankcase oils.

A waste oil collector from the Boston area who oils roads in New England and upstate New York indicates that he uses waste water-soluble cutting oils, waste crankcase oils, terminal waste oils (from the oil-water separator on a water effluent), and oils from tank cleaning operations. The oil applied to a given road depends on the availability of oils at the time of the oiling and follows no particular pattern.

Application rate is apparently related to the qualitative judgment of the operator of the truck doing the oiling, and ranges from 0.025 - 0.05 gallon per square foot of road surface, with the 0.05 figure being used on the test roads.

3. Oil in the Road Surface: Concentration vs. Depth

The two test roads were sampled in four oiled locations and in two unoiled locations to determine concentration of hydrocarbons vs. depth. In all oiled locations, the top inch of road surface showed

the greatest concentration of oil, an average of 0.74% wt. with trace quantities of oils at lower depths (which may be contamination attributable to the sampling technique). The road surface material was made up predominately of clay, with some sand. No attempt was made to characterize the material in more detail. Complete sampling data is presented in Table 1.

4. Estimate of Oil Remaining in Test Road

Oil Applied

0.05 gal/ft.² per application
 2 applications/yr x 12 yrs = 24 applications
 0.05 x 24 = 1.2 gal/ft.² total applied oil
 1.2 gal/ft.² x 9 ft.²/yd.² = 10.8 gal/yd.²
 Oil penetrates 1 inch; consider unit of road surface to be 1 yd.³ and be of dimensions 1 yd wide, 36 yds long and 1 inch deep
 10.8 gal/yd.² x 36 yd.²/yd.³ (for depth of 1 inch) = 388.8 gal/yd.³ road surface

Oil weight:

Oil sp. gr.: 0.904
 Water weighs 8.337 lb/gal
 Oil weighs 0.904 x 8.337 = 7.537 lb/gal

Weight of Oil Applied = $388.8 \frac{\text{gal}}{\text{yd}^3} \times 7.537 \frac{\text{lb}}{\text{gal}}$

For 12 yrs. of application = 2930.25 lb oil/yd.³ road surface
 For 20 yrs. of application = 4883.9 lb oil/yd.³ road surface

Oil Remaining in Road

Wt of road surface:

Avg. soil sp. gr. = 2.75
 $2.75 \times 62.4 \frac{\text{lb}}{\text{ft}^3} \times 27 \frac{\text{ft}^3}{\text{yd}^3} = 4,644 \frac{\text{lb}}{\text{yd}^3}$

Oil in Road Surface: Avg. concentration = 0.74% Wt.
 (neglecting wt. of water in soil)

$0.0074 \frac{\text{lb oil}}{\text{lb road surface}} \times 4,644 \frac{\text{lb road surface}}{\text{yd}^3 \text{ road surface}}$
 = 34.37 $\frac{\text{lb oil remaining}}{\text{yd}^3 \text{ road surface}}$

TABLE 1

PENETRATION OF OIL INTO ROAD SURFACE

<u>Station</u>	<u>Hole</u>	<u>Depth (Inches)</u>	<u>Hydrocarbons mg/kg</u>
1	1	Surface	6,313.17
		4	18.04
		6	18.53
	2	Surface	12,572.70
		4	26.42
		6	52.62
	3	Surface	8,254.50
		4	88.72
		6	7.67
	4	Surface	5,880.24
		4	70.71
		6	7.65
	5	Surface	13,441.25
		4	39.95
		6	67.63
	6	Surface	2,555.91
		4	59.87
		8	9.35
		10	12.15
2 Control	1	Surface	347.76
		4	0
		6	0
	2	Surface	131.04
		4	0
	3	Surface	211.83
3	1	Surface	1,586.22
		6	354.40
	2	Surface	9,437.94
		4	805.74
		6	198.35
	Surface	Surface	6,222.52
		4	276.21
4 Control	1	Surface	142.72
		6	10.04

Percent of Oil Applied Which Remains

$$= \frac{34.37}{2930} \times 100 = 1.17\% \text{ assuming 12 yrs of oiling}$$
$$= \frac{34.37}{4884} \times 100 = 0.7\% \text{ assuming 20 yrs of oiling}$$

5. Oil Volatility

To estimate the level of volatility of waste oil applied to Readington Township roads, a laboratory weathering experiment was performed. Waste oil obtained from the waste oil collector, and being of a "typical" composition of approximately 20% #6 sludge and 80% waste crankcase oil was placed in shallow 11" x 14" laboratory pans under infrared lamps and in the draft of a fan. The surface temperature of the oil was held at 100°F for a duration of 288 hours to achieve a high, though arbitrary, weathering stress. At the end of the weathering period, a 16 - 18% change in weight of oil was noted.

Waste oil obtained from a local service station was weathered under the same conditions for a period of 360 hours and changed weight by 7 - 9%. Exact weathering figures are presented in Table 2.

6. Runoff Mechanisms

To observe runoff mechanisms of oiled roads, a laboratory tank with two compartments was filled with compacted clay material and sand material, respectively in the two compartments. No attempt was made to characterize the materials in the tank more precisely than "sand" and "clay". The tank was so arranged that for each compartment, there was a "road surface" of dimensions 13" x 35" and 18" deep, with a false bottom in the tank arranged to divert any penetrating fluids to a collection bottle below the tank. The surface of the material in the tank was sloped such that runoff of waters and oils could be contained in a large bottle adjacent to the tank.

Each "road surface" was roughened to simulate a lightly scarified condition as observed on the test roads. Oil was applied to each tank compartment at a rate of 0.05 gpf. The tank was then allowed to stand indoors for a period of three days. "Rain" was applied, corresponding to the June and July rainfall averages for the Flemington area, (See Table 3) on each of two days to the oiled sand and clay compartments. "Rain" and oil were applied through appropriate spray nozzels from pressurized containers. It is recognized that application rates of oils to sand roads may differ from those

TABLE 2
WEATHERING DATA

<u>Test No.</u>	<u>Oil Type</u>	<u>Temperature °F</u>	<u>Time (hours)</u>	<u>Weight Loss %</u>
1	1*	90	72	5.97
2	1*	100	360	9.05
3	1*	100	360	7.29
4	2**	100	288	18.15
5	2**	100	288	16.43
6	2** (Applied to clay)	100	354	16.13
7	2** (Applied to clay)	100	354	17.07

* Local service station
** Waste oil collector

TABLE 3
RAINFALL DATA, FLEMINGTON, NEW JERSEY

Month	1931 - 1960	1951 - 1960 Averages	
	Average (in.)	# Rains > 0.1 in.	# Rains > 0.5 in.
January	3.32	6	2
February	2.78	7	2
March	3.99	8	4
April	3.80	9	3
May	4.01	6	3
June	3.80	6	2
July	4.52	6	3
August	5.02	7	3
September	3.59	5	2
October	3.32	6	3
November	3.74	7	3
December	3.42	6	3
TOTAL	45.31		

of clay roads and that rainfall averages for sandy soil areas may be slightly different. However, the intent of the experiment was observation of mechanisms rather than quantification. Oil was again applied at the above rate and "rains" corresponding to the August and September rainfalls were applied and collected. Complete data is presented in Table 4.

The principal observations derived from this experiment were:

- a. The oil penetrated the clay to a depth of about 1 mm below the scarified level.
- b. Even though the surface was scarified, the oil ran off the clay during application and "puddled" in the lowest portion of the road surface.
- c. Application of "rain" to the clay road washed oil from the puddled area and leached oil from the clay surface. Additionally, some oil-wet particles floated with the rain runoff and were carried from the road surface.
- d. There was no penetration of oil or water entirely through the clay column.
- e. The oil penetrated the sand "road surface" to a depth of a few grain diameters, and was evenly distributed over the sand with no puddling.
- f. Application of "rain" caused the flotation of oil-wet sand particles, which were then carried with the rain runoff into the collection container.
- g. Some leaching of oil from the sand was observed, however, the predominant mechanism of oil transport from the sand road surface was by flotation of oil-wet sand particles.
- h. After application of two simulated monthly rainfalls (June and July), approximately 20% of the total quantity of oil-wet sand particles had been transported by runoff from the road surface.
- i. Ten liters of water penetrated the 18 inch deep column of sand. The water contained 12.2 ml of hydrocarbon material.

TABLE 4
LABORATORY RUNOFF STUDY

<u>Time</u> (days)	<u>Oil Applied</u> (ml)	<u>"Rain" Applied</u> (l)	<u>Runoff</u>			
			<u>Sand</u>		<u>Clay</u>	
			<u>Water</u> (l)	<u>Oil</u> (ml)	<u>Water</u> (l)	<u>Oil</u> (ml)
0	600	-	-	-	-	-
3	-	28.3	20.5	80.2	26.0	37.5
4	-	33.7	20.9	101.2	32.5	15.8
5	600	-	-	-	-	-
6	-	37.4	31.5	77.1	37.0	89.7
7	-	26.7	19.5	29.5	23.4	5.3

Total water penetration through the sand column was 10.0 liters of water containing 12.2 ml of hydrocarbons. No penetration was observed through the clay column.

7. Biodegradation

The rate of biodegradation of the oils in the surface of the road material will depend principally upon the presence of hydrocarbon consuming microorganisms, the moisture content of the soil, the presence of the nutrient materials, nitrogen and phosphorous, and ambient temperature. No attempt was made to estimate the amount of total applied oil which has been biodegraded in the road surface. It is our opinion that biodegradation will account for a small amount of the oil loss, in relation to other physical oil movement mechanisms such as volatilization and runoff. It should be noted that the road surface moisture content is low when the oil is applied, and that when rain occurs physical mechanisms are predominate.

8. Adhesion to Vehicles and Dust Transport

It is recognized that oil is transported along the test road by adhesion to tires and underbodies of passing vehicles, and redeposited in some manner. However, no satisfactory method has been defined to account for such transport. Similarly, it is felt that some oil may adhere to dust particles and be transported by wind from the road surface (see below), but no quantitation of this mechanism was attempted.

9. Analysis of Trace Quantities of Crankcase Oil in Runoff Waters

A stream which receives runoff waters from one of the test roads, Woodschurch Road, was examined to determine if crankcase oils were present. Two oil patches each of several square inches in area and having "rainbow" colors were noted in shallow pools on the banks of the small stream. Presumably, the oils were deposited in their noted locations during a period of high stream flow. Sampling and analysis of the oil patch indicated that the sample hydrocarbons bore great similarity to the hydrocarbons extracted from the surface material of Woodschurch Road. In addition, the sample hydrocarbons were similar to waste crankcase oil, but different from ten other common oils tested including #2 and #6 fuel oils. Analysis was made by comparing the fluorescent spectral properties of the known materials with those of the sample.

10. Lead in Soils and Plants

Waste crankcase oils have been reported to contain up to 1% lead by weight² (See Table 5). If ecological damage were to result from the application of waste oils to roads, the high lead content of the oils could have significant bearing on that damage. Therefore, tests were made to determine if the lead was leaving the road. Samples were taken from oiled and unoled stretches of

road, from drainage ditches at the sides of the roads, from a field 150 feet away from the oiled road, and at the outfall of a pipe carrying runoff water from several hundred feet of oiled road. Lead analyses of plant and soil samples from these areas are presented in Table 6. Some of the more significant results are:

- a. The average lead concentration in the oiled sections of road was 209.25 mg/kg as compared to an average lead concentration in the un-oiled sections of 39.0 mg/kg.
- b. The soil samples taken in the (wheat) field 150 feet from the road show an average value of 24.0 mg/kg which is somewhat higher than the expected background for the soil near a rural road.³
- c. The plant samples taken in the same field as (b) above showed an average lead concentration of 33.5 mg/kg, which is higher than the expected background level.³
- d. A possible explanation of (b) and (c) above is that there may be a transport mechanism in effect which associates lead (and/or oil) with dust particles which are blown from the road surface by wind. The field is higher in the overall drainage pattern than the road.
- e. The soil samples taken at the outfall of the drain pipe carrying runoff water from the road showed an average lead concentration of 87.0 mg/kg.
- f. Lead level in the oil sample provided by the waste oil collector averaged 350 ppm for three replicates.
- g. Lead level in the waste oil from the local service station was 525 ppm average for three replicates. (Results by atomic absorption spectrophotometer.)

11. Biological Assessment of Lead in Test Aquatic Organisms

Aquatic organisms from a stream passing beneath one of the test roads (Foot Hill Road) were analyzed for lead content (See Table 7). A small stream passed perpendicular to the oiled road, and drainage from the road entered the stream at the crossing. The stream uphill of the test road did not receive

TABLE 5
TYPICAL COMPOSITION OF WASTE CRANKCASE OILS
From FINAL REPORT OF THE API TASK FORCE ON USED OIL DISPOSAL

Port Mobil Test Fuel Inspections

	Waste Oil (Weighted Average of Four Deliveries)	No. 6 Fuel
Gravity, °API	24.6	15.7
Viscosity @ 100°F, CS	53.3	915.7(1)
Viscosity @ 100°F, SUS	248	4239
Viscosity @ 210°F, CS	9.18	33.5
Viscosity @ 210°F, SUS	56.4	158
Flash Point, °F	215 (C.O.C. Flash)	192 (P.M. Flash)
Water (by Distillation) % Volume	4.4	
BS&W, % Volume	0.6(2)	0.7
Sulfur, % Wt.	0.34	1.9
Ash, Sulfated % Wt.	1.81	0.08
Lead	1.11% Wt.	59 ppm
Calcium, % Wt.	0.17	-
Zinc, % Wt.	0.08	-
Phosphorous, % Wt.	0.09	-
Barium, ppm	568	-
Iron, ppm	356	-
Vanadium, ppm	<5	440

(1) Viscosity, Furol @ 122°F. 188

(2) Poor Separation on Waste Oil

TABLE 6
LEAD ANALYSIS RESULTS

	<u>Sample Number</u>	<u>Lead Content mg/kg</u>
Woodschurch Road	1	184.0
Oil Road Surface	2	223.0
Foot Hill Road	3	172.0
Oil Road Surface	4	258.0
		Avg = 209.25
Foot Hill Road	5	36.0
Unoiled Road Surface	6	42.0
		Avg = 39.0
Woodschurch Road		
Drainage ditch bottom soil	7	42.0
(Rocks, hard soil)	8	59.0
		Avg = 50.5
Drainage ditch	9	42.0
Plants from side	10	16.0
		Avg = 29.0
Foot Hill Road	11	122.0
Drainage ditch bottom soil	12	150.0
(Soft soil)		Avg = 136.0
Woodschurch Road		
Samples from field 50 yds. from road		
Soil	13	25.0
	14	23.0
		Avg = 24.0
Plants (wheat stubble)	15	32.0
	16	35.0
		Avg = 33.5
Soil samples from field at end of	17	96.0
drainage culvert (carrying runoff)	18	78.0
		Avg = 87.0
Waste oil samples from waste oil collector	19	350 ppm
20% #5 Fuel Oil sludge		(Avg of 3 applications)
80% Waste crankcase oil		
Waste oil from local service station	20	525 ppm
		(Avg. of 3 applications)

any other runoff and was, therefore, designated "control". The stream section downhill from the test road received the runoff from approximately 1,000 feet of 12 foot wide road, of which roughly 500 feet had been oiled. This stream section was designated "contaminated". A variety of aquatic organisms with varying feeding habits were collected, classified and analyzed for lead content from each of the stream sections. Collections were made approximately 100 yards upstream from the road on the control side, and approximately 200 yards downstream on the "contaminated side".

The results of the lead analysis of tissues of the sample aquatic invertebrates are at best sketchy. These data are not consistent with some of the control taxa exhibiting higher lead concentrations than the same taxa from the exposed section of the stream.

The herbivorous mayflies from the "contaminated" area tend to have more lead in their tissues than do the control organisms (see pairs 1 and 2), but the predatory dipteran, Tipula, and the stoneflies, which contain the carnivor, Acroneuria, show a reverse trend (see pairs 3 and 4). The filter-feeding blackflies exhibit more lead from the exposed area, possibly indicating a transport of lead in suspension, but the web building caddis fly, Cheumatopsyche, shows a slight reversal of this tendency (see pairs 5 and 6). The omnivorous crayfish show no difference in lead content (see pair 7).

12. Estimate of Lead Remaining in Test Road

Total Lead Applied

Total oil applied: $2930 \frac{\text{lb oil}}{\text{yd}^3 \text{ road surface}}$

Lead = 0.7% oil by wt.

$0.007 \times 2930 = 20.51 \frac{\text{lb Pb}}{\text{yd}^3 \text{ road surface}}$

Lead Remaining in Road

Pb in oiled surface	
Avg. concentration:	290.25 mg/kg

Pb in unoiled surface	
Avg. concentration:	<u>39.0 mg/kg</u>

Net lead contributed by oil:	170.25 mg/kg
------------------------------	--------------

TABLE 7
ANALYSIS OF AQUATIC ORGANISMS FOR LEAD

<u>TAXA</u>		<u>CONTROL</u>			<u>CONTAMINATED</u>		
<u>Pair</u> <u>No.</u>		<u>Dry Wt.</u> <u>gm</u>	<u>No.</u> <u>in sample</u>	<u>Pb</u> <u>ppm Dry Wt.</u>	<u>Dry Wt.</u> <u>gm</u>	<u>No.</u> <u>in sample</u>	<u>Pb</u> <u>ppm Dry Wt.</u>
1	<u>Stonema</u> herbivorous mayfly nymphs	.107	10	14.22	.064	6	46.36
	<u>Ephemerella</u> herbivorous mayfly nymphs	.104	904		.087	382	
2	<u>Ameletus</u> herbivorous mayfly nymphs	.122	151	20.74	.095	68	38.14
	<u>Paraleptophlebia</u> herbivorous mayfly nymphs	.065	75		.023	28	
3	<u>Acroneuria</u> carnivorous stonefly nymphs	.073	8	54.8	.156	17	41.28
	<u>Allocaonia</u> herbivorous stonefly nymphs	.116	165		.062	97	
4	<u>Tipula</u> carnivorous crane fly larvae	.159	3	44.03	2.066	14	17.42
5	Simuliidae filter feeding black fly larvae	.701	2075	14.26	.063	207	71.43
6	<u>Cheumatopsyche</u> web-feeding caddis fly larvae	.059	76	50.80	.088	60	45.45
7	<u>Cambarus bartoni</u> omnivorous crayfish adult	2.771	4	19.84	1.546	1	18.11

$$0.00017 \frac{\text{lb Pb}}{\text{yd}^3 \text{ road}} \times 4,644 \frac{\text{lb road}}{\text{yd}^3 \text{ road}}$$

$$= 0.789 \frac{\text{lb Pb}}{\text{yd}^3 \text{ road}}$$

Percentage of Pb Applied which Remains

$$\frac{0.789}{20.51} (100) = 3.85\%$$

13. Sampling Procedures

Road Surface

The test roads were sampled for concentration of hydrocarbons at various depths. Six inch diameter holes were bored in the road with a portable gasoline powered post hole auger. After scraping the sides of the hole to remove extraneous material, 50 - 100 gram samples were removed from the sides of the hole at the depths of interest. The "surface" sample was made up of a composite of surface material from the top inch of road. Other samples were taken from approximately one onch thick layers of road material, with the center of the layer being at the depth of interest. The holes were bored as deep as was possible with the equipment used; the road was apparently underlain with a very hard material which was impenetrable to the borer.

Samples for Pb were taken from the road surface only. All road samples were placed in plastic bags for transportation to the laboratory.

Soil

The soil samples in the drainage ditches and at the discharge end of the drainage culvert were taken by dislodging a small amount of (frozen) soil with a pick, and placing the sample in a plastic bag. The soil samples from the wheat field 150 feet from the road were taken from cultivated soil by the same technique. Samples were placed in plastic bags for transportation to the laboratory.

Plants

Plant samples collected in the field 150 feet away from the road were from the previous year's growth of wheat, and were taken by breaking off the wheat stalk at the ground, and placing the sample in a plastic bag. Grass samples from the drainage ditches were taken by breaking off the grass at the soil line by hand, and placing the samples in plastic bags.

Aquatic Organisms

Benthic organisms were sampled by disturbing the stream bottom material and allowing the organisms to be collected in a 500 μ mesh sampling net. The samples were preserved at the sampling site in 70% ethanol.

14. Analysis Techniques

Hydrocarbons

Hydrocarbon material was extracted from samples with carbon tetrachloride (4 extractions at 25 cc each for a 1 liter sample), and the infrared spectral peak at 2930 cm^{-1} compared to the peak of known concentrations of similar oils in similar solvent.

Lead

Samples were prepared in accordance with ASTM designation D-1548-63 (for vanadium, adapted by the Edison Laboratory for lead). The detection method was atomic absorption spectrophotometry.

SECTION V

DISCUSSION

When attempting to quantify the oil runoff from the test road, it is obvious that only a small fraction of the oil applied to the road can be accounted for as remaining in the road and volatilizing. Unfortunately, no satisfactory scheme can be found to account for oil transported from the road by adhesion to vehicles and dust transport, nor can the effect of biodegradation be easily quantified. It is therefore impossible to assign a numerical value to the amount of oil which runs off the road by subtracting the sum of other effects from the amount of oil applied.

However, Figures 2 through 5 clearly indicate that oil moves from the surface of the test road with rain runoff, and analytical results presented above indicated that oil found on the banks of a stream receiving runoff from the test road is similar in composition to oil extracted from the test road surface.

It is the opinion of this investigator that volatilization, adhesion to vehicles, and biodegradation taken all together probably account for only 25 - 30% of the oil applied to the road surface. The 70 - 75% of the oil applied which leaves the roads by dust transport and runoff could have significant ecological effects as a result of the oil or its accompanying heavy metals, or both.

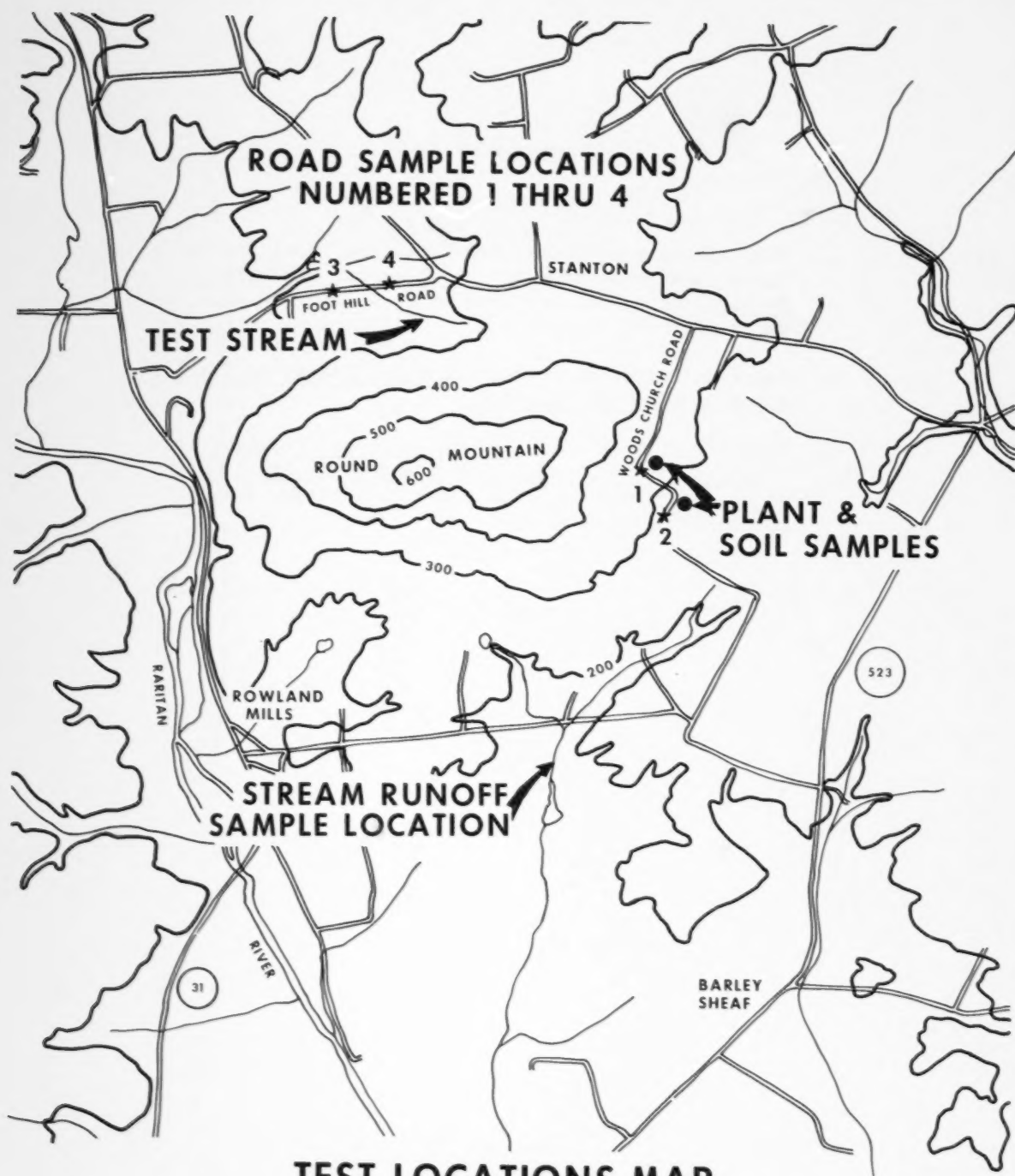
It seems significant to relate that the rural roads in question are oiled twice yearly to suppress dust. The oilings are performed in late June and late August, which indicates that the oil has lost its capability to suppress dust during July and August, and from August to June. It seems fair to assume that the predominant mechanisms of oil loss from the road in the summer are volatilization and possibly dust transport. During the other months, rain runoff is most likely the predominant mechanism, since roughly 80% of the yearly rainfall occurs during the months September through June (see Table 2). In leaving the road through the various mechanisms described, the oil does not perform its intended function of dust suppression, however, it does pose a significant threat of ecological damage.

SECTION VI

REFERENCES

1. U.S. Attorney's Office, New York, New York. Estimate based upon Study of Waste Oil Disposal Practices in Massachusetts, January 1969 by A. D. Little, Inc. and other sources.
2. American Petroleum Institute, Final Report on the Task Force on Used Oil Disposal.
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**TEST LOCATIONS MAP
ADAPTED FROM THE
FLEMINGTON, N.J.
U.S.G.S. QUADRANGLE**

Figure 1



Figure 2

Woodschurch Road looking north from our sampling station. Bluish tint on road surface is due to oil. Photo taken after a light rain, and six months after the last oiling in August 1971.

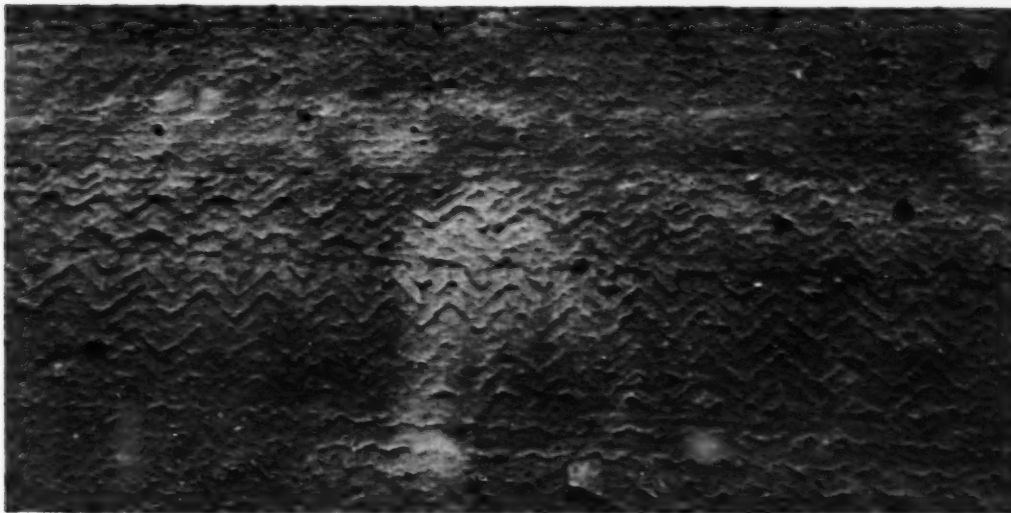


Figure 3

Blue oil patch has been squeezed from soft road surface material by compression of vehicle tires. When walking on oiled sections of this road, one's footprints become tinted bluish.



Figure 4

Oil on puddle surface, Woodschurch Road.

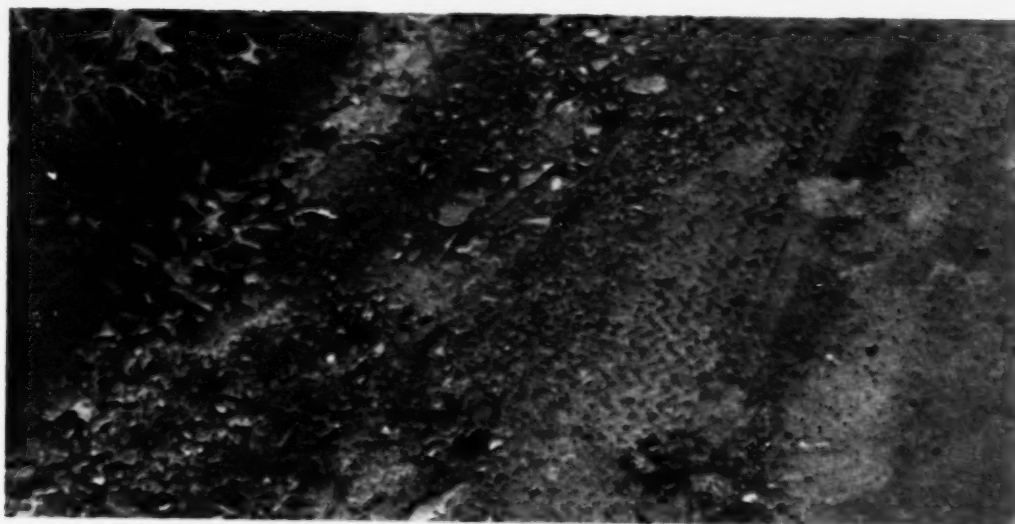


Figure 5

Oil which has been squeezed from road surface material
moves with water runoff toward drainage ditch at the
side of the road.

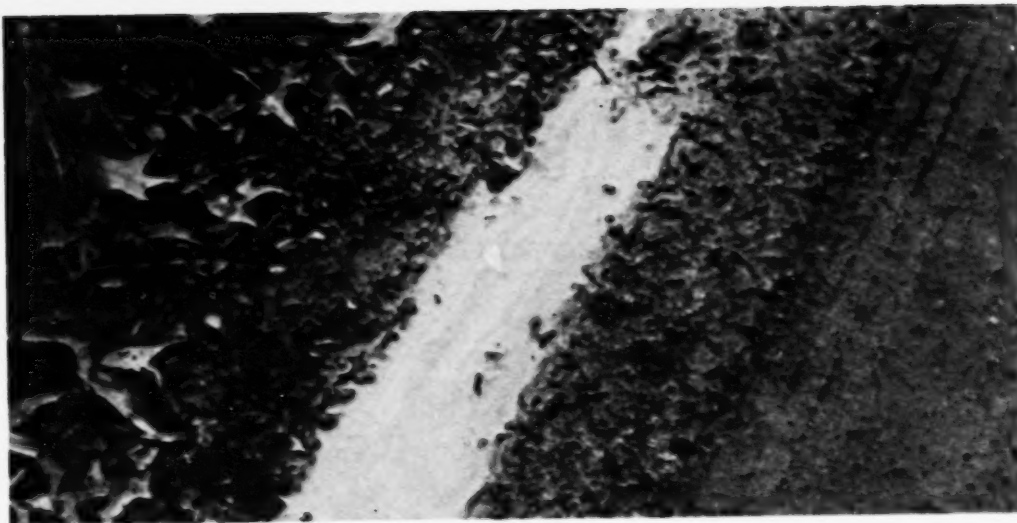


Figure 6

Oil on the surface of a drainage ditch at the side of the road. This oily water will be transported from this ditch into streams during periods of rain.